

Experimental Studies in Quantitative Genetics

I. Reasons for the research

Basic quantitative genetics in corn is being done at some institutions in the U.S., particularly at North Carolina where emphasis is given to breeding methodology. The experimental schemes being employed and material under investigation in the U.S. is, of necessity, restricted with regard to genetic diversity among types adapted to different regions. While the information being sought will be of tremendous value, both in providing genetic understanding and as the basis for development of breeding techniques, it is not likely to have general applicability to the corns of Central and South America. The kind of information being sought in quantitative genetics research in the U. S. programs is also needed for the Latin American programs. The nature of the action of genes in the corn is of prime importance in understanding the genetics of these races as well as providing a sound and efficient basis for utilizing them in local and U. S. breeding programs. Further, it is not possible to move these corns to the U. S. or other areas where they are not adapted and do the required research. The programs of study must be carried out where the races have evolved if reliable and meaningful information is to be developed. However, the program does envisage movement of the exotic types into regions of non-adaptation as attempts are made to incorporate the germ plasmas into U. S. corns. This latter phase of the work will have more concern with possible utilization of Latin American corns to broaden the genetic base of more highly evolved varieties.

One of the most important justifications for the studies to be outlined below is their use in providing theses topic for Latin American students who will be working for the M.S. and PhD degrees in Latin America and U. S.

institutions. This will provide a variety of opportunities for students to be involved with basic genetic research at the graduate level and should lead to the kind of development in their thinking that will be of most value in their future employment. The students chosen to do advanced study in the U. S. will have the opportunity to carry out the experimental work on a thesis problem at a Latin American center and have a problem that is fully acceptable at the U. S. university.

Examples of the kinds of questions for which information is needed are:

1. What is the nature of heterosis in the inter- and intra-racial crosses?
2. What is the relationship between the heterosis among racial crosses and proposed evolutionary development of the races?
3. Is the nature of gene action similar in ancient and modern races?
4. How important is additive genetic, dominance and epistasis in the actions of genes conditioning the expression of the quantitative traits such as yield?
5. What is the potential improvement in yield within races of maize and how does this differ in ancient and modern complex races?
6. Does the genetic variability of potential usefulness increase and how much with inter-crossing of races?
7. Presumably strong linkage complexes exist and may persist for long periods in interbreeding populations of the Latin American corns. What effects do the linkage effects have on mean and variance estimates of the genetic effects in different kinds of populations and generations?
8. How can the exotic and exotic x U. S. corn interbreeding populations be manipulated to increase recombinations and attainment of

linkage equilibrium? (Possibility of incorporating factors such as ~~recombination~~ ^{genetic} ~~variable~~ ^{rate} for increasing recombination rates.)

9. What is the potential value of races of maize in Central and South America for corn improvement throughout the world?

Some examples of the kinds of studies that are visualized are outlined below. In some instances work has already been initiated and others, studies are in the planning stages. The program of work given is for Mexico and involves the races of maize of that country. Some of the same type of investigations are planned for other centers in South America with other materials and it is intended for these plans to serve as examples of types of research needed. The details on the procedures of a specific study will be developed with the Latin American project leader.

II. Studies to be conducted

A. Heterosis in inter- and intra-racial crosses.

1. Inter-racial crosses

An important question in basic genetics and applied breeding is the nature of heterosis and mean yield performance of racial crosses. Evidence from inter-crossing of U.S. open-pollinated varieties indicates heterosis in yield, measured from mid-parent, may be from 10% - 20%. The yield performance of U. S. variety crosses has, in some instances, approached that of commercially important double cross hybrids. Preliminary information from the Mexican corn program indicates that race crosses may excel, by as much as 25%, the yield of the adapted commercial hybrids. In order to survey the races and their crosses it is proposed to do the following

a. Make all possible crosses among the 25 basic Mexican races.

A "representative" type will be chosen for each race in order to proceed with this study. A minimum of 100 plants will be used as female parents in making the racial crosses and efforts

will be made to have many more individual plants represented. Equal quantities of seed from each of the pollinated ears will be bulked for testing.

b. Inter-regional crosses

The 25 races will be crossed with selected broad-base entries from other areas; e.g. Southern U.S. prolific variety cross (Jarvis x Indian Chief), corn belt synthetics (Iowa stiff stalk synthetic) and other corn belt composites involving elite lines, Superior varieties from Columbia, S. A.

c. Evaluation of race crosses

1. The 300 crosses of the 25 races, the races themselves and inter-regional race and variety crosses will be studied in replicated yield performance trials at high, medium and low altitudes in Mexico. Some superior hybrids, adapted to the region of the tests, will be included. It is anticipated that poor performance may result from inter-crosses of non-adapted types. However, the first performance study will be attempted with all possible crosses (reciprocal crosses not distinguished) in order to provide the preliminary evaluation. Repeat evaluations planned for future years will be reduced to types where first year evaluation indicated sufficiently high performance to warrant further testing.

The results will provide information on

- (a) genetic diversity among the races as reflected in heterosis
- (b) indications as to which races should be chosen for more intensive basic genetic studies

- (c) possible races for base populations to be utilized in breeding programs

2. Intra-racial crosses

Many collections (varieties) of various races are presently available and being maintained. While it is planned in other areas of research of the Inter-American Maize Program to develop composite interbreeding pools of germ plasm, evaluation studies are necessary on certain collections of varieties within the races. It is proposed to study variety crosses within some of the races to provide information on the genetic diversity among such varieties. The studies will be the basis for decisions on

- (a) Necessity for maintaining separate germ plasm pools with the race
- (b) The validity of present racial classifications (Implications to be derived from inter- and intra-racial crosses)
- (c) Preliminary information on racial origin. Varieties that are apparent mixtures of two or more races compared to true intra-racial collection will be of interest in this regard.

Materials to be studied in the immediate future are

- (a) All possible crosses among 12 varieties within Tuxpeno. This study will include the varieties, variety crosses and certain adapted hybrids
- (b) All possible crosses among 10 varieties of Salvadoreno

Evaluation trials will include varieties, variety crosses, and race composite crossed with a series of other races

(c) Variety x tester evaluation

A series of studies would utilize elite varieties such as Ver. 131, Azteca, and AES801 which would be used as common testers of groups of varieties with certain races.

B. Nature and magnitude of genetic variability

The relative amounts of various kinds of genetic variances in the basic races of maize is of importance in fundamental genetics and breeding methodology. It is proposed that extensive genetic variability investigations be conducted on a limited number of races in the Inter-American Maize Program. In general, these studies would not be initiated until preliminary investigations of the races and racial crosses have been conducted. Also, the development of suitable composites of collections within the races would have already been done. While the preliminary work and ideal composites are not yet available in the Mexican program, it is proposed to proceed with some intensive genetic variability studies. It is likely that sufficient information is already available to enable the choice of suitable stocks.

1. Design I studies

It is proposed to follow the scheme presently being used at North Carolina for the conduct of these studies. Biparental groups of half- and full-sib families will be produced in each population for evaluation in field trials. Sixty-four male groups, four females per male, will be utilized with two to four replications of each entry. Studies will, in so far as possible, be conducted at two or more locations and in different years. Populations to be used in the initial phase of the work in Mexico are:

- (1) Tuxpeno
- (2) Chalqueno
- (3) Conico
- (4) Hal-tel
- (5) Tuxpeno x Hal-tel

These populations represent the range of races of maize from the ancient indigenous to the modern incipient and complex forms. The information within each population will indicate:

- (1) Amounts of additive genetic variance enabling prediction of possible progress from various selection schemes.

with the race and contribute heavily to the dominance variance in either true dominance at the genic level or effects of linkage may reflect in these estimates. Epistatic variance may also be important and contribute to the variance estimates.

(3) Effects of previous selection on races within Mexico and comparisons of selection consequences with exotic and U. S. populations

Comparison of estimates between races is important to provide information on:

- (1) Nature of genetic variances as a consequence of racial evolution.
- (2) Potential breeding value of different kinds of races in terms of possible selection programs and germ plasma to be utilized.
- (3) Effects of racial mixing and hybridization on genetic variability.
- (4) Necessity for utilizing different breeding schemes with different kinds of races.

C. Breeding Methodology

1. Mass selection

It is likely that mass selection will be effective in the improvement of yield in many of the exotic races of Latin America. The initial and continued progress will depend upon the availability of additive genetic variance within the populations. Mass selection should be initiated and continued for several cycles to provide an evaluation of rate and ultimate progress in yield improvement with such material.

The studies would be conducted with part of all of the following:

- a) Tuxpeno
- b) Chalqueno
- c) Conico
- d) Hal-tel
- e) Tuxpeno x Hal-tel

These populations are chosen in order that information derived in (B) and (C) will have cross interpretations of importance to genetic understanding as well as practical breeding value. In regard to the latter, frequency of favorable genes will be accumulated and result in material of increasing value for breeding stocks.

D. Inter-racial Gene Action

Two or more races would be chosen to be used in series of studies that will utilize inter- and intra-racial entries at different generations. The races to be used will be selected on the basis of the inter-racial cross study and the choice should be made of races indicating different kinds of gene action operating in the race crosses.

Some studies to be conducted are:

(1) Inbreeding depression with different levels of heterozygosity parents (races), F_1 , F_2 , first and second back crosses, F_1 selfed, and F_2 selfed generations would be utilized.

(2) Effects of inter-mating on gene complexes.

The material to be utilized would be parents (races = A & B), $F_1 = A \times B$, $F_2 = AB_2$ and various advanced generations that have been produced by sib mating e.g. AB_6 , AB_{10} . Also, it may be desirable to include the two kinds of backcross entries, ABB and AAB. These would also be advanced to the 6th and 10th generations with random mating.

This study would provide information on:

(1) Optimum mixing time in racial crosses-linkage effects.

(2) Possible effects of epistasis.

(3) Rate of dissipation of heterosis.